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FOREST INSECT INVESTIGATIONS

MOUNTAIN PINE BEETLE CONDITIONS

CRATER LAKE NATIONAL PARK

SEASON OF 1928

by

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Assistant Entomologist

Forest Insect Laboratory
Stanford University, California
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SUMMARY

1. The following report presents a summary of the history of mountain pine beetle depredations in the lodgepole pine stands of Crater Lake Park and its environs, a review of control work carried out on these areas during the past few years, and an account of present infestation conditions, together with recommendations for future management.

2. Epidemic infestations of the mountain pine beetle have been continuous in the lodgepole stands of this region for the past fifteen years. They have resulted in the death of from 70% to 90% of the older lodgepole pine trees on 35,920 acres within the park and 12,800 acres in adjoining national forest lands.

3. Control work was started by the Park Service in the spring of 1925 in the south half of the park. This work was continued in 1926 and 1927. A total of 9,696 infested trees were treated at a cost of \$11,845. A small amount of control work was done in 1926 by the Forest Service in the stands bordering Diamond Lake in the Umpqua Forest. Control work bordering the park control areas on the Sand Creek plateau was carried out by the Forest Service in 1927 and 1928. A total of 5,200 trees were treated at an expenditure of \$4,000. These control operations resulted in a greatly decreased infestation on the control areas. However, the benefits of this work have been largely nullified by reinfestations of beetles from untreated infestations outside the control areas.

4. The original sources of the present infestation now encroaching on the control areas were the old epidemic centers north of Crater Lake. No control work was ever done on these areas because of considerations stated in previous reports. The lodgepole stands in these northern centers were practically killed out by 1927. About this time new centers of infestation started up on the Castle Creek drainage and the divide west of Anna Spring, three to four miles distant, west and southwest of the dead forests. These new centers are now in epidemic condition and threaten to advance into the recreational areas south of Crater Lake, where control work was carried on in 1925-1927.

5. The status of the present infestation in the park and the adjacent lodgepole stands was revealed by a survey of the entire region made in August 1928.

The amount of the 1928 infestation on all these areas is estimated at 4,800 trees. There are epidemic infestations on local areas in the national forests surrounding the park. These centers are located near Diamond Lake and Mt. Thielsen, north of the park, and on Sand Creek near the East Entrance.

6. The future development of the present infestation will probably result in the decimation of the lodgepole forests on the entire south half of the park.

7. Three plans of future management are suggested:

(1) Intensive control at an early period in all the areas infested at the present time. This plan requires the cooperation of the Forest Service in control on adjacent national forest infestations. This is the only plan offering early and adequate control of the present infestation.

(2) Control on the recreational areas only. This can be done at the minimum expense and without cooperation of other timber owners, though it would be necessary to clean up dead trees on the same areas each year. This plan can only temporarily check the infestation on the areas worked.

(3) To do no control work, relying on a natural subsidence of the infestation. If this course is followed practically all the mature trees will be killed, unless the epidemic dies down from natural causes.

At the present time artificial control of the character suggested in the first plan appears the most desirable, and is recommended.

MOUNTAIN PINE BEETLE CONDITIONS

CRATER LAKE NATIONAL PARK,

SEASON OF 1928

Introduction

Depredations of the mountain pine beetle, Dendroctonus monticola Kop., have been continuous in the lodgepole pine (Pinus contorta Loud.) stands in Crater Lake Park and its immediate environs for the past fifteen years. The annual losses have been of such magnitude as seriously to deplete the older stands of lodgepole over vast areas in this region. The result is that great tracts of the former lodgepole stands are now dead forests. This condition is particularly true of the entire north half of the park and in certain local areas in the western and southern parts. These losses have not, however, been confined to the park, since contiguous stands in both the Crater and Umpqua National Forests have also suffered. In the vicinity of Diamond Lake, in the latter forest, the beetle infestations have been very destructive.

The depredations of these beetles and the consequent losses of large areas of forest led to the inauguration of control operations, begun in the spring of 1925 and designed to reduce these losses and prevent further spread of the infestation. Now, after three years of intensive control operations, it is desirable to give an account of present conditions in order to check the effects of the control work and to serve as a guide for future management.

The present paper reviews the history of the project and presents a description of present barkbeetle conditions in the park and contiguous territory, together with a suggested plan of management.

Historical Review of Origin of Project and Control Work

The present widespread devastation in the forests of this region was anticipated in 1923 by the park superintendent and the local Forest Service officers. At that time Colonel Thomson, superintendent of Crater Lake Park, realizing the menace to the surviving lodgepole stands, consulted with representatives of the Bureau of Entomology relative to measures to relieve the situation. As a result of this step a preliminary beetle survey of the park and adjacent territory was made in 1924 by J. E. Patterson of the Bureau of Entomology. This survey yielded data upon which recommendations for artificial control of the beetle were made. Acting upon the advice in these recommendations, a federal appropriation of \$5,000 was secured by the Park Service and allotted to Crater Lake Park for the purpose of conducting control work during the season of 1925.

Since it was realized at this time that sufficient funds could not be secured to make possible control work in all the infested areas in the park, it was necessary to limit this work to the smaller infested areas south of the lake where the greatest measure of relief could be secured with obtainable funds. The plan of control did not provide for operations throughout the park, as it was not considered feasible to attempt control work in the large devastated areas north of the lake because of the great expense this would entail, and also because the greater percentage of the trees in these stands had already been killed. The plan, however, did provide for a thorough clean-up on the more important recreational areas south of Crater Lake. Thus the original plan of attack was aimed at the following objective: to cover thoroughly by control work all the infested areas south of the lake, treating as many of the infested trees as it was possible to locate, thereby relieving this part of the park of immediate menace and preventing the infestation in these areas from building up to the status represented in the stands north of the lake. The infested areas south of the lake involved in this plan were located at the East Entrance, in Pinnacles Valley, Munson Valley, and at Anna Spring. Since these areas were fairly well isolated by topographic and type barriers, it was hoped that following control work they would remain free of reinestation by beetles from the untreated infestations north of the lake.

Control work by the Park Service was begun on the areas recommended for treatment in May 1925. This work was continued until July 10. The season's operations resulted in the treatment of 4,291 infested trees, at a cost of \$5,761.64. Later in the season it was found that some reinestation had appeared on the control areas, partly as a result of trees missed in the first operation, but more especially from beetles flying in from untreated areas. This necessitated further work in 1926. Continued reinestation of the control areas from outside infestations in 1926 made it necessary to continue operations in 1927. A total of 2,469 infested trees were treated in 1926 at a cost of \$3,583.52; and 2,936 trees, costing \$2,500, were treated in the 1927 operations. During the three-year period a total of 9,696 infested lodgepole pine trees were treated, at a total cost of \$11,845.16.

As a result of these operations the infestation in the fall of 1927 on the control areas was very light, and it was believed that effective control of the beetles had at last been secured. The prospects for this result were considerably increased by the partial removal of the epidemic infestation on the Sand Creek area in the Crater National Forest, which adjoined the park control at the East Entrance and in Pinnacles Valley.

Control work on the Sand Creek area was started in the spring of 1927 and continued during the spring of 1928. These operations were carried out by the Forest Service and the objective was to remove the infestation on the national forest lands, which was a source of continual reinestation of the park control areas. The control operations in the Sand Creek area have so far resulted in the treatment of approximately 5,200 infested trees, at a cost of \$4,000.

Statistics of the preceding control operations are given in Tables I and II. The treatment of the infested trees on both projects was accomplished by the solar heat method of barkbeetle control. In the application of this method the direct rays of the sun are utilized to kill the beetle broods, obviating the use of fire or the necessity of peeling the logs.

In addition to the control operations in the lodgepole pine stands in the park, a small amount of control work was done in the yellow pine at the South Entrance. The incipient infestation in this stand was caused by the western pine beetle, Dendroctonus brevicomis Lec. The area was controlled during the 1926 operations by treating 43 infested trees at a cost of \$300. The results of this work were permanent, as no infestation has since appeared on the area.

The Survey of 1928

In order to present a complete account of present barkbeetle conditions in the lodgepole pine forests of the park and its immediate environs, a careful survey of this entire region was made in August 1928.

The areas covered include the entire lodgepole pine stand within the park and the contiguous stands in the Crater and Umpqua National Forests. These latter areas include the region adjacent to Diamond Lake, the drainage of the Upper Rogue River and the Sand Creek Plateau.

The survey methods used consisted of mapping each separate stand of lodgepole pine and estimating the acreage. The data secured showed the extent of dead forests killed by the beetles in previous years, the location and intensity of the present infestations, and the location of stands susceptible to attack which have not yet been invaded. The number of trees in the infested areas that contained broods (representing the present infestation) was determined by making an intensive survey of local areas in which each infested tree was examined and tabulated, and by running strips entirely through each infested area. From this basis the total number of infested trees in each area was estimated.

Since the survey was made in August 1928 the data secured on the present infestation are fairly complete, as practically all the beetle broods are at this time established in the attacked trees.

Present Conditions in the Park

The present conditions in the lodgepole pine stands throughout the north half of the park can be described in a few words. Out of a total area of 36,000 acres of lodgepole pine, 33,000 acres have been swept by the beetles, and these stands are now practically dead forests. Only two small infested areas remain of the recent widespread infestation in this region. One of these stands is located on the west slope of Timber Crater and the other is at a point on the lake rim north of Cleetwood Cove. With the passing of the present generation of beetles these areas will contain only dead trees.

There are now only two uninfested stands north of the lake. These are on the headwaters of National and Crater Creeks, and their greater bulk lies outside the park in the Crater National Forest. Their combined area does not exceed 2,500 acres. Up to the present time these stands have no infestations.

It is evident that the infestation in the north half of the park has run its course and will practically cease to exist with the current season, since there will be left very few trees susceptible to attack. No control work has ever been done in this part of the park.

In striking contrast to these conditions are those found in the forests of the south half of the park, particularly in the drainage basins of Castle and Anna Creeks southwest of the lake. The present beetle infestation in these areas is highly epidemic; and since it is largely in the initial stages, with a high percentage of trees yet to be attacked, it is quite probable that it will continue unabated until the forests in these basins have been killed. The initial infestation on these areas appears to have developed in 1926 on the north fork of Castle Creek. Since then the beetles have killed all the susceptible trees on an area of 1,200 acres. The present infestation centers around this dead forest, though it has spread south as far as White Horse and to a point on the Cascade Divide west of Anna Spring. These latter areas were invaded during the season of 1928, and it is here that the highest losses in the park are occurring at the present time. The only evident source of this infestation is the decimated stands north of the lake. That the infestation was originally built up by beetles migrating from these old areas is further borne out by the fact that the movement of the infestation in the park has been toward the south. Because the only part of this new infestation that menaces the control areas of the park has developed since 1927, when the last control operations were carried on, there has been no control work done on these areas.

The present infestation on the recreational areas south of Crater Lake, where the control operations of 1925-1927 were carried out, is active but well below an epidemic status. These areas are located at Anna Spring and in Munson Valley, on the Anna Creek drainage; in Kerr Valley, Pinnacles Valley and at the East Entrance, on the Sand Creek drainage. There was a highly epidemic infestation on these areas in 1925, when the first control work was started. These same areas were reworked in the control operations of 1926 and 1927. It is due to these continued efforts that the present infestation in these stands is not now epidemic. The amount of control work done from 1925 to 1927 is given in tabular form in Table I.

However, there is an active infestation on local areas of these control units which has perhaps been developed from two sources. Some of it is the result of infested trees that were missed in the last (1927) control work, while beetles flying in from outside sources account for the remainder. Beetles from west of the lake (Castle Creek areas) have doubtless invaded the Anna Spring area and Munson Valley, and others have come into Pinnacles Valley from the uncontrolled national forest areas north of Sand Creek.

Amount of Present Infestation

Data secured in the recent survey make it possible to estimate the amount of the present infestation fairly closely. The estimates of the number of infested trees per each infestation unit follows:

Unit	Previous Conditions	Number of Infested Trees in 1928
Pinnacles Valley	Control work done in 1925 and 1926	500
Munson Valley	Control work done in 1925, 1926 & 1927	700
Anna Spring	Small part of present area controlled in 1925 and 1926	500
Union Peak (on divide west of Anna Spring)	Not infested prior to 1928	1,000
White Horse and drainage of Castle Creek	Infestation started in N. part in 1926, spread S. in 1927	2,000
	Total	4,500 trees

The location of these areas is shown on the infestation map, which also indicates the location of the present infestation relative to the beetle-killed forests and the susceptible stands which have not yet been infested.

Present Conditions in National Forests Adjoining the Park

By referring to the control and type map it will be seen that the infested lodgepole pine stands extend outside the park into the Umpqua, Deschutes and Crater National Forests. Past infestations of the mountain pine beetle have resulted in the killing of large areas in certain of these stands, particularly in the vicinity of Diamond Lake in the Umpqua Forest and on the Sand Creek plateau in the Crater Forest. Infestations in these stands have a direct bearing on conditions in the park, since the lodgepole stands are continuous. A comprehensive beetle survey must of necessity consider these outlying stands and infestations, since they are an important part of the infestation as a whole. Though past beetle losses on these lands in the Umpqua Forest have been high, the present infestation is far less than that of former years, a condition which is mainly the result of natural causes. A small amount of control work was done by the Forest Service in 1926 in the stands bordering Diamond Lake. The results of this work, while beneficial, could hardly be expected to affect greatly the status of the infestation, since only a few hundred trees were treated. The present condition of light infestation on the Diamond Lake drainage is largely the result of

a shifting of the infestation to other stands, mainly to the east slope of Mt. Thielsen in the Deschutes Forest. This infestation has not disappeared. Rather, the beetles have migrated to more susceptible stands in the general area. Present conditions in the Diamond Lake region are on the whole not greatly changed, except that the present infestation is farther removed from the park forests, and is therefore less of a menace than formerly. The extent of the infestation north of Diamond Lake was not determined, though it is believed to continue for several miles.

The present infestation on the Sand Creek Plateau in the Crater Forest is less than that of former years, a condition directly due to the control work done on this area in 1927 and 1928 by the Forest Service, which has been previously reviewed. This control work has been successful in arresting the epidemic and has prevented a progressive spread into surrounding stands. During the early years of the park control project this infestation yearly contributed beetles to the park control areas, resulting in their annual reinestation. It was mainly to prevent this spread and to protect the scenic attractions on Sand Creek that the control work was undertaken by the Forest Service, because these stands have practically no commercial value. Since the centers of infestation have been broken up by control work conditions have greatly improved. Another season's control operations on this area should result in effective control of the infestation.

The stands of lodgepole on the upper Rogue River drainage in the Crater Forest have not as yet been invaded by the mountain pine beetle, though epidemic infestations are on their border. If these infestations spread westward considerable damage will result, since merchantable stands of western white pine of high value are mingled with the lodgepole. This species is also subject to attack by the beetle, and heavy losses often occur.

The extent and location of the lodgepole stands, present infested areas and beetle-killed stands outside the park are given in Table VI, Appendix.

Probable Future Developments

Future developments in the lodgepole forests of Crater Lake Park and its immediate environs cannot be predicted with absolute certainty. There are no indications that the present epidemic infestations will subside through natural causes until the stands susceptible to beetle attack are killed. Such has been the history of the former infested stands attacked during the past fifteen years. There appears to be little doubt that the same cycle will be repeated in the areas now infested and also in the stands adjoining them.

The present epidemic centers within the park are located largely in the recreational areas, and the present trend of the infestation is toward these sites because the more susceptible, or older, trees happen to be in these places. Since dead forests on these important sites are the probable ultimate result of the beetles' present activities, it is important that an early decision be made on the problem of whether the stands on these areas are to be preserved or the beetles allowed to take their toll.

Recommendations

In the future management of the lodgepole forests of the park there are three courses of action open. These are outlined in the following paragraphs and are suggested for the consideration of the National Park Service:

Plan 1 - The carrying out of immediate control work on all infested areas.

Plan 2 - Control work on recreational areas and at administrative headquarters only.

Plan 3 - To do no further control work, relying on a subsidence of the infestation through natural causes.

The following considerations may be helpful in arriving at a decision as to which of these three courses will best meet the needs of the present situation.

In any event the north half of the park may be disregarded, since there are now no living lodgepole trees large enough to be attacked in this part. Therefore the problem of future management is confined entirely to the south half of the park.

Since there are no present indications that the infestations will subside through natural agencies, but will probably continue until the forests on the recreational areas of the park are largely killed, it would seem that Plans 1 and 2 should be given first consideration. In considering these plans separately, emphasis is given to Plan 1, since it provides for a thorough clean-up of the entire infestation in a short period before the stands are greatly reduced.

It must be remembered that the original plan of control adopted in 1925 and followed throughout the recent control operations was similar to Plan 2 and did not provide for the treatment of all the infested areas. No control work was done north of Crater Lake, and not until 1927 on Sand Creek, though the recreational areas in the south half of the park were thoroughly cleaned. The fact that they are now again partially infested proves the futility of attempting permanent control of an area where even rather remote epidemic infestations are left.

Effective and permanent control should result from operations conducted under Plan 1. The work must be complete, and because it will be located largely on the recreational sites only such methods should be used as will leave the treated areas in the best possible condition for this use. Control methods insuring these conditions cost more than those employed in commercial forests. The cost per tree would be about \$2. The number of infested trees that it will be necessary to treat under Plan 1 is estimated at 4,500, so it is probable that an initial allotment of \$9,000 would be required for the first work.

In the event that this plan is adopted it would also be necessary to secure the cooperation of the Forest Service, so that control work would be continued on the Sand Creek project.

Plan 2 can be recommended only as a substitute in case lack of funds makes it impossible to undertake a thorough clean-up of the park. It cannot be expected to eliminate the beetle infestations, but would result in saving many mature trees and would greatly reduce the amount of standing dead timber on the recreational areas. The plan could be carried out with less cost, as operations would be limited to the main recreational areas. Under this plan only Anna Spring, the upper end of Munson Valley and the camp sites on Lost Creek in Pinnacles Valley would be treated. The present infestation on these areas is estimated at 500 trees, and about 1,000 would be required to treat these areas. The effects of this work would not, however, be permanent, and it would probably be necessary to treat the same areas each year.

Last experiences in control work against the mountain pine beetle in lodgepole pine infestations have shown that it is necessary to carry on maintenance control for a few years following the first campaign. Maintenance work would be necessary under both Plans 1 and 2; for Plan 1 its cost would amount to about \$2,000 per year, and it should be carried on for at least two years following the first work. Under Plan 2 the work of the first year would have to be repeated each year thereafter for an indefinite period, since some reinestation would occur from untreated areas.

Under Plan 3 no control work is suggested. It has been previously pointed out in this report that the probable final result of the present infestations, unless they are artificially controlled, will be the killing of all the older trees in the south half of the park. Conditions on these areas will at that time be comparable to those north of Crater Lake, where 90 per cent of the stand is now dead. It is possible that nature may bring about a balance, causing the infestation to subside before the stands are greatly decimated. Even if this does not occur, and the lodgepole stands are killed, such stands are soon replaced, either by the same species or by other types, such as fir and hemlock. These latter species are better park trees and are not subject to barkbeetle epidemics.

APPENDIX

Tables of statistics on control work carried out in the park by the National Park Service, in the adjoining national forests by the Forest Service; the present infestation in these areas, the acreage of dead forests and of the uninfested stands subject to infestation.

Maps:

- A - Mountain pine beetle infestation map of Crater Lake Park, showing past and present distribution of the mountain pine beetle infestation in lodgepole pine stands.
- B - Control and type map of Crater Lake Park and environs, showing distribution of lodgepole pine, location of past and present beetle infestations and areas where control operations have been carried out.

TABLE I

Park Service Control work, 1925 to 1926 - in Park

Number of trees treated on control areas each year
and percentage of reduction secured

Area	No. of Trees Treated			No. of Infested Trees on Area in Fall of 1925	Percentage of reduction from peak of infestation secured by Control work
	in Control Operations 1925	1926	1927		
Giant Entrance	1,815	838	93	30	90%
Pinnacle Valley	832	97	72	190	78%
Kerr Valley	853	438	801	225	68%
Munson Valley	801	594	290	120	69%
Crater Peak	—	324	2,062	500	71%
Anna Spring	23	74	106	300	178%
	4,291	1,715	2,936	1,600	

TABLE II

Park Service Control Work - In Park

Number of trees treated each year, acreage covered,
and annual cost of operations

Year and Season	Trees Treated	Acreage Covered	Cost
1925 - Spring	4,291	5,900	\$ 5,761.64
1926 - Spring and summer	2,469	5,900	3,593.52
1927 - Spring	2,926	5,900	2,860.00
	9,686		\$11,215.16

Team and drivers	transit	average	cost
1927 - Spitaling	4,000	2,000	\$5,000.00
1928 - Spitaling	1,267	400	1,000.00
1929 - Spitaling	6,267		\$6,000.00

Number of miles traveled, average covered and cost of operation

Power Service Control Block
on land road area, number, average

Table III

TABLE IV

Present Infestation on Park Areas

Number of trees attacked in 1928 and acreage of each infested area

Unit Area	Infested Acreage	Beeber Trees Attacked in 1928	Character of Infestation
Pinnacles Valley	2,000	500	Active
Munson Valley	960	700	Active
Anna Spring	200	300	Active
Union Peak (on divide west of Anna Spring)	960	1,000	Epidemic
White Horse and drain- age of Castle Creek	2,000	2,000	Epidemic
	7,100	4,500	

TABLE V

Present Status of the Park Lodgepole Forests

Acresage uninfested, infested at present time, and acreage totally killed

Status	Acreage	Location
Uninfested	15,360	South and west of Crater Lake
Infested in 1939:		
Spidemic and	3,940	Southwest of Crater Lake
Native	3,260	South and southeast of Crater Lake
Dead Forest	33,920	Mainly north of Crater Lake
	56,220	

Sequoia	Total acreage : 1,160,000	Location and Sequoia National Forest	In Dugway Creek drainage of Mono Lake and Inyo National Forest	In Dugway Creek drainage of Mono Lake and Inyo National Forest	In Dugway Creek drainage of Mono Lake and Inyo National Forest	Unforested 44,500	Forested 19,200	Forested 640	Forested 4,300	Forested 12,800	Forested 900	Forested 50,740	Forested 51,960	Forested 51,240

average undifferentiated, unforested at present time, and average totally hillside

Forest Status of the National Forest Lands
including Great Lakes Park Forest

TABLE 17